GZA

HEALTH RISK ASSESSMENT FOR LEAD
BIO ENERGY
WEST HOPKINTON, NEW HAMPSHIRE

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ABBREVIATIONS AND TERMS USED IN REPORT

AAL	Ambient air limit, which is the maximum 24-hour or annual average concentration allowed under New Hampshire's air toxics program, Chapter Env-A 1400 of the New Hampshire Code of Administrative Rules.
ACGIH	American Conference of Governmental Industrial Hygienists
ALM	Adult Lead Model
Ambient concentration impacts or ambient impacts	The predicted concentration in the atmosphere attributable to a particular facility or process.
CDC	Centers for Disease Control
cm	Centimeter
Cs	Cumulative soil concentration
Dry and wet deposition	Dry deposition is the depositing of particles on the ground during dry conditions as a result of gravitational settling. Wet deposition is the depositing of particles on the ground as a result of being scavenged by precipitation.
EPA	United State Environmental Protection Agency
Geometric Mean and Geometric Standard Deviation	Geometric mean and geometric standard deviation are the parameters that define the distribution of values in a log-normal distribution. Blood lead levels have been observed to follow a log-normal distribution, which is similar to the bell-shaped curve that defines the more familiar normal distribution, except that the log-normal distribution forms a bell shaped curve when the logarithms of the values are plotted. The log-normal distribution can be described with two parameters, the geometric mean and the geometric standard deviation, which are analogous to the arithmetic mean and standard deviation used to described the normal distribution. The geometric mean describes the central tendency of the distribution, and it is equivalent to the median, meaning that half the values in the distribution are above the geometric mean and half the values are below the geometric mean. The geometric standard deviation describes the spread of the distribution. With the geometric mean and the standard deviation of a log-normally distributed set of data, the probability of being above or below a certain value can be calculated. For example, 50 percent of all values in a log-normal distribution will be less than the geometric mean and 95 percent of all values (95^{th} percentile) will less than the geometric mean times the standard deviation raised to the 1.645 power (95^{th} percentile = GM x $GSD^{1.645}$).
HHRAP	Human Health Risk Assessment Protocol
IEUBK	Integrated Exposure Uptake Biokinetic
ks	Soil loss constant
ksl	Soil loss constant due to leaching
ksr	Soil loss constant due to runoff
mg/kg	Milligrams per kilogram. Equivalent to parts per million (ppm) on a weight basis.
NHANES III	National Health and Nutrition Evaluation Survey
NHARD	New Hampshire Air Resources Division

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NHDES	New Hampshire Department of Environmental Services
NHDPHS	New Hampshire Division of Public Health Services
OSHA	Occupational Safety and Health Administration
PbB	Blood Lead
tD	Time period of combustions
Unitized	In this document, unitized refers to ambient concentration impacts and deposition rates predicted using an emission rate of one gram per second (1 g/s). The unitized value is multiplied by the emission rate in grams per second to calculate the predicted ambient impact or deposition rate.
Zs	Soil mixing zone depth
$\mu g/c^3$	Micrograms per cubic meter
$\mu g/dl$	Micrograms per deciliter. In this report, this is the unit used for the lead concentration in the blood.

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1.0 SUMMARY

GZA GeoEnvironmental, Inc. (GZA) was retained to evaluate the health risks associated with the emissions of lead from the Bio Energy, LLC (Bio Energy) facility in West Hopkinton, New Hampshire. This risk assessment was conducted in accordance with U.S. Environmental Protection Agency (EPA) guidance (1994, 1998, 2002a, 2003a). The results of the risk assessment indicate:

- The concentrations of lead potentially emitted from the Bio Energy[1] facility do not pose a human health risk based on predicted blood lead (PbB) concentrations from assumed exposure to emitted lead.
- Predicted PbB concentrations for people near the Bio Energy facility are significantly below the Centers for Disease Control (CDC) threshold of concern of 10 micrograms per deciliter (μg/dl) PbB and the EPA-recommended target levels for PbB.
- With the Bio Energy facility operating at its maximum allowable emission rate, there is a 99.99-percent probability that a child living at the predicted location of maximum lead deposition would have a PbB level less than 10 μg/dl.

1.1 METHODOLOGY

In accordance with EPA guidance, this risk assessment makes a number of conservative assumptions that together overstate actual risks that are likely to occur. The risk assessment evaluated operation of the facility with predicted deposition of lead for individuals exposed in the areas of highest impact. Emissions from the Bio Energy facility were predicted with the facility operating at its maximum allowable lead emission rate. Health risks were evaluated for people at those locations where the impacts of the Bio Energy facility were predicted to be highest. This included off-site risks in the industrial area surrounding the Bio Energy plant, where wet deposition is the predominant impact, and those agricultural/residential areas where the highest wet deposition, dry deposition, and ambient concentration impacts were predicted to occur. The results of the analysis, in the form of PbB levels, take into account not only predicted emissions from the Bio Energy facility, but also exposure to other sources of lead in the environment, including lead in soil and food not affected by emissions from the facility.

In the industrial area surrounding the Bio Energy facility, there are no residences, and health risks were evaluated for adult workers using EPA's Adult Lead Model (ALM). For the agricultural/residential areas, health risks were evaluated using EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model for a resident child with a default diet, a resident child with a diet that includes locally grown produce, and a subsistence farm child.

[1] Emissions from the Bio Energy facility were modeled using EPA's ISC3 model. Total deposition, wet deposition, dry deposition, and ambient concentrations were predicted with this model. The methodology and results of the modeling are described in Air Quality Dispersion Modeling – Ambient Air and Deposition Impacts prepared GZA GeoEnvironmental, Inc. (2004).

1.2 RESULTS OF HEALTH RISK ASSESSMENT

In the industrial area, the geometric mean adult PbB level predicted by the ALM for the background case ranges up to 1.8 μg/dl and the predicted 95th percentile PbB level ranges up to 7.0 μg/dl. The fetal PbB level among adult workers ranges up to 6.3 μg/dl for the background case. The corresponding ranges for adults in the industrial area with the Bio Energy facility operating operating are a geometric mean of up to 1.8 μg/dl and the predicted 95th percentile adult PbB level of up to 7.1 μg/dl. The corresponding PbB level among adult worker fetuses ranges up to 6.4 μg/dl, indicating a very small incremental change in PbB levels in the industrial area as a result of the facility. All of these estimates are below the CDC level of concern for children of 10 μg/dl and EPA's recommended target level for PbB.[2]

For the agricultural/residential exposure scenario, the highest impacts from the Bio Energy facility were predicted for a resident child (default and local diet). The predicted PbB levels without exposure to the Bio Energy facility are a geometric mean PbB of up to 1.8 μg/dl and a 95th percentile of up to 4.1 μg/dl. With the Bio Energy facility operating, based on the location with the highest dry deposition rate, and assuming that the highest ambient impacts occurred at the same location, the geometric mean PbB levels for resident children range up to 2.0 μg/dl depending on the child's age (corresponds to children aged 1 to 2 years). The 95th percentile PbB levels range up to 4.6 μg/dl with the higher end of the range corresponding to younger children (1 to 2 years).

The maximum predicted PbB levels are summarized in the table below:

Scenario	Background Case (μg/dl)	With Bio Energy Operating (μg/dl)	Increment (μg/dl)	CDC Level of Concern for Children and Pregnant Women (μg/dl)
Adult in Industrial Area				
Adult Geometric Mean	1.6 – 1.8	1.6 – 1.8	0.0	10
Adult 95th Percentile	5.3 – 7.0	5.5 – 7.1	0.1 – 0.2	10
Fetal 95th Percentile	4.8 – 6.3	4.9 – 6.4	0.1	10
Resident Child at Location of Maximum Dry Deposition				
Geometric Mean	1.1 – 1.8	1.2 – 2.0	0.1 – 0.3	10
95th Percentile	2.5 – 4.1	2.8 – 4.6	0.2 – 0.7	10

Note: Based on Bio Energy operating for a period of 20 years.

In the industrial area, the ambient concentration impact and dry deposition from Bio Energy are essentially zero. For this health risk assessment, GZA used the New Hampshire Department of Environmental Services (NHDES)-identified background concentration for lead in New Hampshire soils of 51 mg/kg[3] (NHDES, 2001) plus the emissions-related deposition concentrations to evaluate lead exposures in the industrial area. Wet deposition from the Bio Energy facility operating at its permit limit resulted in an estimated soil lead concentration

[2] The EPA target is for an individual child to have no more than a 5-percent probability of having a PbB level exceeding the CDC's concern threshold of 10 μg/dl (USEPA, 1994). The probability for an individual child having a PbB level greater than 10 μg/dl in the residential/agricultural area is much less than 5 percent (ranges from 0.002 to 0.007 percent depending on diet and location). EPA also states that the 95th percentile PbB level should be less than 10 μg/dl among a population of hypothetical individuals subject to the lead exposure in question (USEPA, 1994). For populations in the residential/agricultural area, the 95th percentile PbB levels were much less than 10 μg/dl.

[3] NHDES-identified soil lead background concentration is a 95th percentile value (NHDES, 2001).

attributable to the facility of 26.3 milligrams per kilogram (mg/kg), which is less than background concentration for lead. The resulting soil lead concentration of 77 mg/kg is within the range of background concentrations for lead in New Hampshire soil of 2 - 570 mg/kg (NHDPHS, 1991), and is less than the EPA action level of 800 mg/kg for industrial land use, and is less than the EPA action level of 400 mg/kg for residential land use.

In the residential/agricultural area, which includes everywhere outside the industrial area surrounding the Bio Energy facility, the worst-case annual ambient impacts from Bio Energy was 0.04 micrograms per cubic meter ($\mu g/m^3$), compared to the NHDES annual Ambient Air Limit (AAL) of 0.12 $\mu g/m^3$. The soil lead concentrations of 64.1 (wet) and 66.1 mg/kg (dry) used in the risk assessment to evaluate lead exposures in the residential/agricultural area account for both background soil lead concentrations (51 mg/kg) and emissions-related deposition concentrations. Highest calculated soil lead concentrations attributable to wet and dry deposition from the Bio Energy facility operating at its maximum allowable emission rate were 13.1 mg/kg (location of maximum wet deposition) and 15.1 mg/kg (location of maximum dry deposition). The soil lead concentration of 64 and 66 mg/kg are within the range of background concentrations for lead in New Hampshire soil of 2 - 570 mg/kg (NHDPHS, 1991), and is less than the EPA action level of 400 mg/kg for residential land use.

These conclusions are based on the findings of the risk assessment described in **Section 2.0.**

2.0 EVALUATING HEALTH RISKS ASSOCIATED WITH LEAD

Risk assessment is "the characterization of the potential adverse health effects of human exposure to environmental hazards" (National Research Council, *Risk Assessment in the Federal Government: Managing the Process.* Washington, DC: National Academy Press, 1983). To evaluate potential health risks associated with proposed lead emissions from the facility, GZA identified health-based standards and guidelines for lead and estimated exposure to populations near the facility. The exposure estimates were used to (1) estimate soil concentrations of lead, and (2) predict PbB levels in these populations. The estimated soil concentrations of lead were compared to EPA action levels and screening levels for the protection of human health for residential and industrial/commercial land uses. Predicted PbB levels were compared to health-protective criteria established by the federal government, as described in the next section.

2.1 HEALTH-BASED STANDARDS AND GUIDELINES FOR LEAD

Target PbB levels have been set by the Occupational Safety and Health Administration (OSHA) for adult workers. OSHA states that the PbB level of workers intending to have children should remain below 30 µg/dl (OSHA, 1991) to protect against adverse reproductive effects.

The American Conference of Governmental Industrial Hygienists (ACGIH) has also identified 30 µg/dl PbB level as a Biological Exposure Index (ACGIH, 2001). OSHA's permissible PbB level in lead-exposed workers is 40 µg/dl; below this level, OSHA states that no further medical monitoring or workplace intervention is required.

The CDC has set a 10 µg/dl PbB level as the threshold level of concern for young children and recommends primary prevention activities at increasing PbB levels (CDC, 1991). For children with PbB levels between 10 and 14 µg/dl, more frequent screening is recommended but no environmental or medical intervention is recommended. Community intervention (*e.g.*, educational programs) is recommended if a significant percentage of children are in the 10 to 14 µg/dl PbB range. The CDC recommends nutritional and educational intervention when children's PbB levels are in the range of 15 to 19 µg/dl. Medical evaluation and environmental remediation should be done for all children with PbB levels equal to or greater than 20 µg/dl (CDC, 1991).

The EPA target is for an individual child to have no more than a 5-percent probability of having a PbB level exceeding the CDC's concern threshold of 10 µg/dl (USEPA, 1994). That is, the 95th percentile PbB level should be less than 10 µg/dl among a population of hypothetical individuals subject to the lead exposure in question.

Although the CDC concern threshold was developed for children, predicted PbB levels for adults can be compared to this criterion as a health-protective measure. If the predicted PbB levels are considered acceptable for children, then they would also be acceptable for adults. EPA recommends 10 µg/dl as a target PbB level for women of childbearing age to insure that fetal PbB does not exceed 10 µg/dl (EPA, 2003a).

EPA has established a risk-based screening level for lead in soil at residential sites of 400 mg/kg. This soil concentration is designed to be protective of children ingesting lead (EPA, 1994) and was calculated using the IEUBK Model. The criterion is based on conservative default assumptions, such as 30-percent lead bioavailability. (Lead in soil bioavailability is often less than 30 percent). EPA states that the action level for lead in soil would not result in PbB levels for children greater than 10 µg/dl. The IEUBK Model is specific to children and cannot be used to predict PbB levels in adults. Other models have been developed for this purpose, as described **in Section 2.3.1**.

EPA has also established an updated risk-based screening level for lead in soil at commercial/industrial (*i.e.*, non-residential) sites of 800 mg/kg. The updated screening level is based on a recent analysis of the combined Phases 1 and 2 of the National Health and Nutrition Evaluation Survey (NHANES III) and is protective for all subpopulations (EPA, 2003b).

2.2 EXPOSURE ASSESSMENT

The exposure assessment component of the risk assessment results in estimates of concentrations of lead in soil and air at locations where people are assumed to have contact with lead based on predicted emissions from the facility. Receptor groups were identified based on EPA guidance requiring evaluation of the most sensitive groups in populations near the facility (EPA, 1998). Concentrations of lead in exposure media were estimated for these receptor groups using the results of modeling performed by GZA using EPA's ISC3 model (presented in separate report: *Bio Energy LLC Air Quality Dispersion Modeling Ambient Air and Deposition Impacts*). The ISC model is the model specifically identified in EPA's *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (HHRAP)* as the model typically used for this purpose (EPA, 1998). Equations from the HHRAP were used to convert the deposition rates predicted by the modeling into media concentrations of lead.

2.2.1 Receptor Groups

Four sensitive receptor groups were evaluated in this risk assessment:

1. Adult workers;
2. Child resident consuming a typical U.S. diet (IEUBK default diet);
3. Child resident consuming some locally grown produce; and
4. Children of subsistence farmers.

The risk assessment was based on the worst-case exposure for each of these groups. These scenarios correspond to the locations where the maximum off-site wet and dry deposition rates and maximum ambient impacts from the Bio Energy facility were predicted to occur.

The Bio Energy facility is located in an industrial area, and there is no residential/agricultural land use within approximately 450 feet (137 meters) of the Bio Energy stack. The likely receptor group in the industrial area is adult workers.

Outside of the industrial area, land use was presumed to be residential or agricultural. The receptor group in these areas is child residents. **Table 1** illustrates the nine possible diet and deposition combinations that were considered for child residents. Although there are other land uses within the deposition area of the facility, the resident and subsistence farmer receptor groups were identified as the most sensitive subgroups based on the assumed higher level of exposure given these land uses. These receptor groups are represented by children, who are more susceptible to the developmental effects of lead. The age range of the children assumed to contact lead is 6 months to 7 years; this coincides with the age range specified in EPA's IEUBK model.

2.2.2 Modeling Results

Details on the ambient and deposition modeling performed by GZA are provided in a separate modeling report (GZA, 2004). In order to evaluate the maximum impacts from the Bio Energy facility, the impacts at the locations corresponding to the maximum annual wet deposition, dry deposition, and ambient impact from the Bio Energy facility predicted by modeling using five years of hour-by-hour meteorological data were identified for each of the two land use areas evaluated (industrial zone and residential/agricultural). In the industrial zone, the maximum predicted ambient impacts and dry deposition are zero, so only the location of the maximum predicted wet deposition rate was evaluated.

In the residential/agricultural area, (*i.e.*, everywhere outside the industrial zone in the immediate vicinity of the Bio Energy facility), the maximum wet deposition rate is predicted to occur 164 meters from the facility. The ambient impact and dry deposition rate at this location are zero.

The maximum dry deposition rate is predicted is approximately 1,860 meters southeast of the Bio Energy facility. The ambient impact at this location is nearly the same as the maximum ambient impact predicted at any location. In order to simplify the evaluation, it was conservatively assumed that maximum predicted ambient impact occurred at the same location as the maximum predicted dry deposition rate. As a result, the residential and subsistence farmer receptor groups were evaluated under three exposure conditions: (1) background conditions without emissions from Bio Energy, (2) the location with the maximum predicted wet deposition impact from Bio Energy, and (3) the location with maximum predicted dry deposition and ambient impact from Bio Energy.

Modeling results used to estimate lead concentrations in soil and air are presented in **Table 2**.

2.2.3 Estimating Media Concentrations

The parameters in the equations used to estimate media concentrations are described in detail in Chapter 5 and Appendix B of EPA's *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (HHRAP)* (EPA, 1998). GZA relied on EPA-recommended values for most parameters and therefore will not repeat this information in this report. Citations to the HHRAP are presented in the text, and supporting calculations are provided in **Appendix A**. For those parameters that depend on site-specific information, such information was used where available, as described below.

The cumulative soil concentration, Cs, was calculated as the highest 1-year annual average soil concentration that would occur at the end of the operating lifetime of the emission source. The time period of combustion (tD in the equation) for this facility is a maximum of 20 years. The equation to calculate Cs (HHRAP, Equation 5-1D) includes soil mixing zone depth (Zs) for which GZA used a depth of 1 centimeter (cm), except for the calculation of lead uptake in locally grown produce and for the evaluation of the soil exposure pathway for the subsistence farmer receptor group, where a tilled soil depth of 20 cm was used (HHRAP, Appendix B, Table B-1-1).

Runoff and leaching are two of the relevant processes that affect the soil loss constant (ks). To calculate ksr (loss constant due to runoff) and ksl (loss constant due to leaching), GZA relied primarily on default values provided in Appendix A-3-128 of the HHRAP. Site-specific parameters used to calculate ksr and ksl and other media concentrations (*e.g.*, produce) are listed in **Table 3**.

The total soil lead concentration that receptor groups were assumed to contact **(Table 4)** was calculated as the sum of the cumulative soil concentration from deposition (Cs) and the pre-existing background concentration of lead in the soil. For example, the Cs for residential land use, based on the maximum deposition rate, is 15.1 mg/kg; this is added to the background concentration of 51 mg/kg for New Hampshire soils to yield a total soil lead concentration for residents of 66.1 mg/kg at this location. The background lead soil concentration of 51 mg/kg is from the NHDES *Contaminated Sites Risk Characterization and Management Policy* (NHDES, 2001) and is considered by NHDES to be representative of rural and suburban locations in New Hampshire. The NHDES-identified background value is a 95th percentile concentration and, therefore, is likely a conservative background.

2.3 PREDICTING BLOOD LEAD LEVELS

Evaluating risks of lead in soil involves prediction of PbB levels and comparison of the predicted levels with health-based criteria. Separate models, specific to adult workers and children, were used to predict PbB levels for populations near the facility.

2.3.1 Predicting Blood Lead Levels for Adult Workers

To evaluate risks from chronic exposures to lead, a model that relates lead concentrations in environmental media to adult PbB concentrations is required. For this analysis, GZA relied on the ALM recommended for use by the EPA Technical Review Workgroup for Lead (EPA, 2003a).

The ALM includes equations that relate PbB levels to baseline exposure to non-site related environmental sources of lead (diet, soil, dust, water, and air). The model can provide typical (geometric mean or median) and high-end (95th percentile) values of the distribution of PbB levels. The total median PbB level for an adult is calculated by adding the background lead exposure (from all environmental exposures) to site-specific lead exposure. A 95th percentile PbB level is calculated by multiplying the total median PbB level and the geometric standard deviation ($GSD^{1.645}$).

In documentation for the model (EPA, 2001), EPA states that, *"The model equations were developed to calculate cleanup goals such that there would be no more than a 5% probability that fetuses exposed to lead would exceed a blood lead (PbB) of 10 µg/dl. This same approach also appears to be protective for lead's effect on blood pressure in adult males."*

For the facility-specific application of the ALM, PbB levels were predicted for adult workers in the industrial zone in the immediate vicinity of the facility using the maximum predicted wet deposition rate (ambient impact and dry deposition were predicted to be zero).

The exposure parameters used in the ALM for adult workers in the industrial zone are presented in **Table 5**. A facility-specific soil concentration of lead (77 mg/kg) was used based on calculations described in **Section 2.2.3** and included in **Appendix A**. EPA default values were used for all other parameters in the model. The baseline PbB (PbB_0 =1.5 µg/dl) and geometric standard deviation (GSD = 2.1) for PbB were selected based on combined data from Phases 1 and 2 of NHANES III (EPA, 2002b).

2.3.2 Predicting Blood Lead Levels for Children

A concise description of the IEUBK Model for lead in children is presented in White *et al.*, 1998:

The model *"was developed to provide plausible blood lead distributions corresponding to particular combinations of multimedia lead exposure. The model is based on a set of equations that convert lead exposure (expressed as micrograms per day) to blood lead concentration (expressed as micrograms per deciliter) by quantitatively mimicking the physiologic processes that determine blood lead concentration. The exposures from air, food, water, soil, and dust are modeled independently by several routes. Amounts of lead absorbed are modeled independently for air, food, water, and soil/dust, and then combined as a single input to the blood plasma reservoir of the body. Lead in the blood plasma reservoir, which includes extracellular fluids, is mathematically allocated to all tissues of the body using age-specific biokinetic parameters. The model calculation provides the estimate for blood lead concentration for that age. This value is treated as the geometric mean of possible values for a single child, or the geometric mean of expected values for a population of children exposed to the same lead concentrations. The distribution of blood lead concentrations about this geometric mean is estimated using a geometric standard deviation, typically 1.6, derived from the analysis of well-conducted community blood studies."*

Consistent with EPA guidance (EPA, 2002a), GZA relied on EPA default values for intake rates, bioavailability and PbB distribution parameters in the site-specific application of the model. For example, GZA used model default values for lead concentrations in water (4 micrograms per liter) and air (0.1 µg/m^3 for background concentration from sources other than Bio Energy). Non-default parameters were used in the model based on site-specific data for lead concentrations in soil (**Table 4**) and for Bio Energy's contribution to air (**Table 2**). The maximum 0.14 µg/m^3 air concentration at the dry deposition location is the sum of the maximum modeled impact of Bio Energy (0.04 µg/m^3, which is the unitized impact times the emission rate) and the IEUBK default background concentration (0.1 μg/m³)[4]. At the other locations evaluated, Bio Energy's ambient air impact was zero, so the ambient concentration consisted solely of the background contribution.

Given that diet is the second largest contributor to total lead exposure evaluated in the IEUBK model (**Figure 1**), three different possibilities for children's diets were considered in predicting PbB levels: (1) the IEUBK default diet; (2) a local resident's diet; and (3) a local subsistence farmer's diet. The default IEUBK diet assumes that children in the area of the plant consume a diet that has a similar lead concentration to the typical United States diet. Lead intake rates for the typical United States diet were updated by EPA using food residue data from the U.S. Food and Drug Administration Total Diet Study (TDS; FDA, 2001) and food consumption data from NHANES III (CDC, 1997) as shown in **Table 6**.

The updated dietary intake rates in the third column of **Table 6** were used as the IEUBK default diet intake rates. The second possibility for a child's diet was a local resident diet. In this case, a child's diet is similar to the typical United States diet except for the assumption that 25 percent of the fruits and vegetables that the child eats are locally grown. This percentage of locally grown produce is recommended in the HHRAP (EPA, 1998) to estimate the diet of a local resident. This scenario does not mean the 25 percent of the child's entire diet is locally grown because NHANES considers fifteen different food types in calculating the typical United States dietary lead intakes. In the local resident scenario, only two of these fifteen food types (fruit and vegetables) are adjusted to represent the inclusion of 25-percent locally grown food. The third diet possibility is the child of a subsistence farmer. Again, some of the food types that are included in the overall diet remain the same as in the default diet; however, in the subsistence farmer scenario, the child is assumed to eat 100-percent locally grown fruit, vegetables, and meat with other food groups coming from non-local sources. The nine diet and deposition cases considered for children living within the deposition area are defined in **Table 1**.

2.4 COMPARISON OF PREDICTED PBB LEVELS TO HEALTH-BASED STANDARDS AND GUIDELINES

The PbB levels predicted by the ALM for adult workers in the industrial area immediately adjacent to the Bio Energy facility are presented and compared to CDC and OSHA health-based criteria in **Table 5**. The predicted geometric mean PbB levels for adult workers range from 1.6 to 1.8 μg/dl and the predicted 95th percentile PbB levels for adult workers range from 5.5 to 7.1 μg/dl. The predicted 95th percentile PbB levels of fetuses of adult workers range from 4.9 μg/dl to 6.4 μg/dl, a predicted increase over the background case 95th percentile of 0.1 μg/dl. The predicted geometric mean and 95th percentile PbB levels for adult workers and adult worker fetuses in the area of the facility are below the OSHA target levels of 30 to 40 μg/dl for adult workers and CDC threshold level of concern of 10 μg/dl for pregnant women and fetuses. Estimated geometric mean PbB concentrations in adult workers (*i.e.*, women of childbearing age) in the absence of exposures to the Bio Energy facility emissions are estimated to be 1.6 to 1.8 μg/dl, which is consistent with the range of the estimated geometric mean PbB levels observed in the NHANES III study of 1.4 to 2.0 μg/dl (EPA, 2002b).

[4] Maximum State-wide quarterly average lead concentrations as measured by the New Hampshire Air Resources Division (NHARD) in 1993 and 1994 and reported in USEPA's AIRDATA database ranged from 0.01 to 0.02 μg/m³, which is well below the default background concentration. Due to the low observed lead concentrations, lead monitoring was discontinued by NHARD in 1994.

The predicted geometric mean PbB levels for resident children in the absence of emissions from the Bio Energy facility range from 1.1 to 1.8 μg/dl and the 95th percentile ranges from 2.5 to 4.1 μg/dl (see **Table 7**). With the Bio Energy facility, the predicted geometric mean PbB levels for resident children range from 1.2 to 2.0 μg/dl and the 95th percentile PbB level range was 2.8 to 4.6 μg/dl for both the default IEUBK diet and the local resident diet scenarios at the worst-case location. The geometric mean and 95th percentile predicted PbB levels in children for all age groups at the locations with highest impacts from the Bio Energy facility are below the CDC threshold level of concern, 10 μg/dl.

Estimated lead concentrations for subsistence farmer children (same as resident children exposure scenarios except for lower dietary lead based on consumption of 100-percent locally-grown produce and meat) are also below the CDC threshold level of concern at the locations with the highest impacts from the Bio Energy facility. The predicted geometric mean PbB level for subsistence farmer children with presumed exposure to emissions from the Bio Energy facility, based on the locations with the highest Bio Energy impacts, range from 1.0 to 1.7 μg/dl. The 95th percentile PbB level range for this case was 2.3 to 3.9 μg/dl. This case reflects a small increment over the background case (0.0 to 0.2 μg/dl increment).

These predicted levels are lower than for the resident child case because the greater amount of locally grown produce consumed, the lower the total dietary intake of lead (see **Figure 2**). Predicted concentrations of lead in locally grown produce are lower than estimated lead concentrations in the nation's food supply (FDA, 2001 and CDC, 1997).

3.0 CONCLUSIONS

The estimated cumulative soil lead concentration in the industrial zone, based on the maximum modeled wet deposition rate, including an existing background of 51 mg/kg, is 77 mg/kg which is much lower than the EPA screening level of 800 mg/kg for soil lead at commercial/industrial (*i.e.*, non-residential) sites.

Based on the estimated soil lead concentrations in the industrial zone, and other conservative inputs into the ALM (**Table 5**), the predicted geometric mean PbB levels in adult workers range from 1.6 to 1.8 μg/dl, and the 95th percentile PbB levels range from 5.5 μg/dl to 7.1 μg/dl. The corresponding 95th percentile blood levels for fetuses of adult workers range from 4.9 to 6.4 μg/dl. The 95th percentile PbB levels for both adult workers and adult worker fetuses are below the CDC threshold level of concern of 10 μg/dl for fetal development. These predicted PbB levels are also well below the ACGIH and OSHA target levels for workers of 30 to 40 μg/dl.

The estimated maximum cumulative soil lead concentration in the residential/agricultural zone, based on the locations with maximum wet and maximum dry deposition and including an existing background of 51 mg/kg, is 66 mg/kg, which is lower than the EPA screening level of 400 mg/kg for residential sites.

Based on the estimated soil lead concentrations, and other conservative default inputs into the IEUBK model, the predicted PbB levels in children are below the CDC threshold level of concern of 10 μg/dl at the locations with the highest impacts from the Bio Energy facility. The highest predicted geometric mean PbB level in children was 2.0 μg/dl (geometric mean for age 1 to 2 years) with a 95th percentile PbB level of 4.6 μg/dl.

The greater amount of locally grown produce consumed, the lower the total dietary intake of lead (**Figure 2**). The predicted concentrations of lead in locally grown produce are lower than estimated lead concentrations in the nation's food supply (FDA, 2001 and CDC, 1997). Predicted lead concentrations are lowest in the food supply for subsistence farmer children assumed to consume 100-percent locally grown produce and meat.

The highest predicted incremental change in PbB level for the age groups evaluated that are attributable to the permitted emissions from the facility is 0.3 µg/dl for geometric mean PbB levels and 0.7 µg/dl for the 95th percentile PbB levels (**Table 7**).

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TABLES

TABLE 1
CHILD EXPOSURE SCENARIOS EVALUATED IN RISK ASSESSMENT

Bio Energy, LLC
West Hopkinton, New Hampshire

Deposition Condition[2]		Diet[1]		
		IEUBK Default[1a]	*Local Resident*[1b]	*Subsistence Farmer*[1c]
	Background[2a]	**Case 1A**	**Case 2A**	**Case 3A**
	Maximum Wet Deposition Location[2b]	**Case 1B**	**Case 2B**	**Case 3B**
	Maximum Dry Deposition Location[2c]	**Case 1C**	**Case 2C**	**Case 3C**

Notes:

1. Dietary intake of lead is the second largest contributor to child lead intake. Three child diet scenarios were considered in this analysis:
   a. IEUBK Default Diet: lead intake from the typical U.S. diet.
   b. Local Resident Diet: 25% of fruit and vegetables consumed are grown locally.
   c. Subsistence Farmer Diet: 100% of fruit, vegetables, and meat consumed are grown locally

2. Three deposition scenarios were used to model soil and air concentrations:
   a. Background condition: background lead concentration in New Hampshire soil of 51 mg/kg (NHDES 2001) was used as the soil concentration, and the default IEUBK air concentration of 0.1 ug/m^3 was used.
   b. Maximum Wet Deposition Location: In tilled soils (20 cm soil depth), 53.5 mg/kg was the modeled soil concentration at this location which is background concentration of 51 mg/kg plus 2.5 mg/kg resulting from deposition. This tilled soil concentration was used for the subsistence farmer diet scenario and all produce pathways. In untilled soil (1 cm soil depth), 64.1 mg/kg was the modeled soil concentration. The untilled soil concentration was used for soil contact in the default and local diet scenarios. The default IEUBK air concentration equal to 0.1 ug/m3 was used plus 0 ug/m3 from facility emissions.
   c. Maximum Dry Deposition Location: In tilled soils (20 cm soil depth), 53.8 mg/kg was the modeled soil concentration at this location which is equal to the background concentration of 51 mg/kg plus 2.8 mg/kg resulting from deposition. The tilled soil concentration was used for the subsistence farmer diet scenario and all produce pathways. In untilled soils (1 cm soil depth), 66.1 mg/kg was the modeled soil concentration. The untilled soil concentration was used for soil contact in the default and local diet scenarios. 0.14 ug/m3 was the modeled air concentration

TABLE 2
EMISSIONS PARAMETERS USED TO ESTIMATE MEDIA CONCENTRATIONS

Bio Energy, LLC
West Hopkinton, New Hampshire

Parameter	Description	Units	Maximum Values: Industrial Zone	Maximum Values: Residential/ Agricultural Location with Maximum Predicted Wet Deposition Rate	Maximum Values: Residential/ Agricultural Location with Maximum Predicted Dry Deposition Rate
		Distance from Source:	**100 meters**	**164 meters**	**1,860 meters**
Q	Emission rate	g/s	0.0756		
Cyp	Unitized maximum annual average air concentration from particle phase	μg-s/g-m^3	0	0	0.522
Dydp	Unitized maximum annual average dry deposition from particle phase	s/m^2-yr	0	0	0.331
Dywp	Unitized maximum annual average wet deposition from particle phase	s/m^2-yr	0.608	0.303	0.017

Source: Bio Energy LLC Air Quality Dispersion Modeling Ambient Air and Deposition Impacts, prepared by GZA GeoEnvironmental, Inc., February 2004.

TABLE 3
SITE-SPECIFIC PARAMETERS USED TO ESTIMATE MEDIA CONCENTRATIONS

Bio Energy, LLC
West Hopkinton, New Hampshire

Parameter	Description	Units	Value	Source
Zs	Soil mixing zone depth	cm	1 20	HHRAP, 1998 Table B-1-1, untilled soil HHRAP, 1998 Table B-1-1, tilled soil
Fv	Fraction of air concentration in vapor phase	Unitless	0	HHRAP, 1998 Appendix A-3-128; metals are assumed to be 100% in particulate phase
RO	Average annual surface runoff from pervious areas	cm/yr	51	USGS. Open Report 96-395. Mean Annual Runoff, Precipitations, and Evapotranspiration in the Glaciated Northeastern United States, 1951-1980. Plate 1.
P	Average annual precipitation	cm/yr	102	USGS. Open Report 96-395. Mean Annual Runoff, Precipitations, and Evapotranspiration in the Glaciated Northeastern United States, 1951-1980. Plate 2.
I	Average annual irrigation	cm/yr	10	http://water.usgs.gov/watuse/tables/irtab.st.html
Ev	Average annual evapotranspiration	cm/yr	48	USGS. Open Report 96-395. Mean Annual Runoff, Precipitations, and Evapotranspiration in the Glaciated Northeastern United States, 1951-1980. Plate 2.

TABLE 4
ESTIMATED TOTAL SOIL LEAD CONCENTRATIONS

Bio Energy, LLC
West Hopkinton, New Hampshire

Land Use, Maximum Deposition Rate	Total Soil Lead Concentration (Bio Energy+background)[1] (mg/kg)	USEPA Screening Level [2] (mg/kg)
Industrial	77.3	800
Residential/Location of Maximum Wet Deposition/Untilled Soil	64.1	400
Residential/Location of Maximum Dry Deposition/Untilled Soil	66.1	400
Agricultural/Location of Maximum Wet Deposition/Tilled Soil	53.5	Not specified
Agricultural/Location of Maximum Dry Deposition/Tilled Soil	53.8	Not specified

NOTES:

1. The background lead soil concentration of 51 mg/kg is from the New Hampshire Department of Environmental Services (NHDES) *Contaminated Sites Risk Characterization and Management Policy* (NHDES, 2001) and is considered by NHDES to be representative of rural and suburban locations in New Hampshire.
2. The Method 1 Soil standard in the NHDES Risk Characterization and Management Policy for all soil exposure categories is 400 mg/kg.

TABLE 5
ADULT LEAD MODEL

Bio Energy LLC
West Hopkinton, New Hampshire

BACKGROUND CONDITION

Exposure Variable	PbB Equation[1] 1*	PbB Equation[1] 2**	Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario: Using Equation 1: GSD = Hom	Using Equation 1: GSD = Het	Using Equation 2: GSD = Hom	Using Equation 2: GSD = Het
PbS	X	X	Soil lead concentration	ug/g or ppm	51	51	51	51
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4	0.4	0.4
GSD_i	X	X	Geometric standard deviation PbB	--	2.1	2.3	2.1	2.3
PbB_0	X	X	Baseline PbB	ug/dL	1.5	1.7	1.5	1.7
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	--	--
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	0.050	0.050
W_S		X	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	1.0	1.0
K_{SD}		X	Mass fraction of soil in dust	--	--	--	0.7	0.7
$AF_{S,D}$	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S,D}$	X	X	Exposure frequency (same for soil and dust)	days/yr	219	219	219	219
$AT_{S,D}$	X	X	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB_{adult}			**PbB of adult worker, geometric mean**	ug/dL	**1.6**	**1.8**	**1.6**	**1.8**
$PbB_{adult,0.95}$			**95th percentile PbB among adult workers**	ug/dL	**5.3**	**7.0**	**5.3**	**7.0**
$PbB_{fetal,0.95}$			**95th percentile PbB among fetuses of adult workers**	ug/dL	**4.8**	**6.3**	**4.8**	**6.3**
PbB_t			**Target PbB level of concern (e.g., 10 ug/dL)**	ug/dL	**10.0**	**10.0**	**10.0**	**10.0**
$P(PbB_{fetal} > PbB_t)$			**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	%	**0.4%**	**1.4%**	**0.4%**	**1.4%**

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).
When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same $PbB_{fetal,0.95}$.

WITH BIO ENERGY

Exposure Variable	PbB Equation[1] 1*	PbB Equation[1] 2**	Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario: Using Equation 1: GSD = Hom	Using Equation 1: GSD = Het	Using Equation 2: GSD = Hom	Using Equation 2: GSD = Het
PbS	X	X	Soil lead concentration	ug/g or ppm	77.3	77.3	77.3	77.3
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4	0.4	0.4
GSD_i	X	X	Geometric standard deviation PbB	--	2.1	2.3	2.1	2.3
PbB_0	X	X	Baseline PbB	ug/dL	1.5	1.7	1.5	1.7
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	--	--
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	0.050	0.050
W_S		X	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	1.0	1.0
K_{SD}		X	Mass fraction of soil in dust	--	--	--	0.7	0.7
$AF_{S,D}$	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S,D}$	X	X	Exposure frequency (same for soil and dust)	days/yr	219	219	219	219
$AT_{S,D}$	X	X	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB_{adult}			**PbB of adult worker, geometric mean**	ug/dL	**1.6**	**1.8**	**1.6**	**1.8**
$PbB_{adult,0.95}$			**95th percentile PbB adult workers**	ug/dL	**5.5**	**7.1**	**5.5**	**7.1**
$PbB_{fetal,0.95}$			**95th percentile PbB among fetuses of adult workers**	ug/dL	**4.9**	**6.4**	**4.9**	**6.4**
PbB_t			**Target PbB level of concern (e.g., 10 ug/dL)**	ug/dL	**10.0**	**10.0**	**10.0**	**10.0**
$P(PbB_{fetal} > PbB_t)$			**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	%	**0.5%**	**1.5%**	**0.5%**	**1.5%**

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).
When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same $PbB_{fetal,0.95}$.

***Equation 1, based on Eq. 1, 2 in USEPA (1996).**

PbB_{adult} =	$(PbS*BKSF*IR_{S+D}*AF_{S,D}*EF_S/AT_{S,D}) + PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

****Equation 2, alternate approach based on Eq. 1, 2, and A-19 in USEPA (1996).**

PbB_{adult} =	$PbS*BKSF*([(IR_{S+D})*AF_S*EF_S*W_S]+[K_{SD}*(IR_{S+D})*(1-W_S)*AF_D*EF_D])/365+PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

Source: U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee
Version date 05/19/03

TABLE 6
LEAD INTAKES FROM TYPICAL U.S. DIET (μG/DAY)

Bio Energy, LLC
West Hopkinton, New Hampshire

Age Category (months)	Previous IEUBK Default Value	Updated Default Dietary Lead Intake Estimate[1]
0 - 11	5.53	3.16
12 - 23	5.78	2.60
24 - 35	6.49	2.87
36 - 47	6.24	2.74
48 - 59	6.01	2.61
60 - 71	6.34	2.74
72 - 84	7.00	2.99

NOTE:

1. The updated dietary lead intake estimates are from Centers for Disease Control and Prevention (CDC), National Health and Nutrition Examination Survey, III 1988-1994. U.S. Department of Health and Human Services, Public Health Service, CD-ROM Series 11, No. 1 (July 1997).

TABLE 7
Predicted Geometric Mean Blood Lead Concentrations for Different Diet and Deposition Scenarios and Incremental Increases in Blood Lead Levels from Background to Deposition Conditions

Bio Energy, LLC
West Hopkinton, New Hampshire

Exposure Scenario:	Case 1A	Case 1B	Case 1C	Case 2A	Case 2B	Case 2C	Case 3A	Case 3B	Case 3C
Child's Diet:	*IEUBK Default Diet*			*Local Resident*			*Subsistence Farmer*		
Deposition Condition:	*Background*	*Location of Maximum Wet Deposition*	*Location of Maximum Dry Deposition*	*Background*	*Location of Maximum Wet Deposition*	*Location of Maximum Dry Deposition*	*Background*	*Location of Maximum Wet Deposition*	*Location of Maximum Dry Deposition*
Percent over 10 ug/dL[1]:	0.003%	0.005%	0.007%	0.003%	0.005%	0.007%	0.002%	0.002%	0.002%
Age Group	**Predicted Geometric Mean Blood Lead Concentration[2] (µg/dL)**								
6 months - 1 year	1.7	1.9	1.9	1.7	1.9	1.9	1.7	1.7	1.7
1 - 2 years	1.8	1.9	2	1.7	1.9	2	1.7	1.7	1.7
2 - 3 years	1.6	1.8	1.8	1.6	1.8	1.8	1.5	1.6	1.6
3 - 4 years	1.5	1.7	1.7	1.5	1.7	1.7	1.4	1.5	1.5
4 - 5 years	1.3	1.4	1.5	1.3	1.4	1.5	1.2	1.3	1.3
5 - 6 years	1.2	1.3	1.3	1.2	1.3	1.3	1.1	1.1	1.2
6 - 7 years	1.1	1.2	1.2	1.1	1.2	1.2	1.0	1.0	1.1
Age Group	**Incremental Increase in Blood Lead Level[3] (µg/dL)**								
6 months - 1 year	--	0.2	0.2	--	0.2	0.2	--	0.0	0.0
1 - 2 years	--	0.1	0.2	--	0.2	0.3	--	0.0	0.0
2 - 3 years	--	0.2	0.2	--	0.2	0.2	--	0.1	0.1
3 - 4 years	--	0.2	0.2	--	0.2	0.2	--	0.1	0.1
4 - 5 years	--	0.1	0.2	--	0.1	0.2	--	0.1	0.1
5 - 6 years	--	0.1	0.1	--	0.1	0.1	--	0.0	0.1
6 - 7 years	--	0.1	0.1	--	0.1	0.1	--	0.0	0.1

Notes:
1. The percent of the population aged 6 months to 7 years that is likely to have a blood lead level greater than 10 µg/dL given each set of exposure assumptions. Exposure scenarios are described in Table 1.
2. Blood Lead concentrations modeled by the IEUBKwin model for each age group and set of exposure assumptions.
3. Incremental Increase in Blood Lead Level = Blood Lead Concentration during Deposition - Blood Lead Concentration during Background Conditions

TABLE 7 (Continued)
Predicted 95th Percentile Blood Lead Concentrations for Different Diet and Deposition Scenarios
and Incremental Increases in Blood Lead Levels from Background to Deposition Conditions

Bio Energy, LLC
West Hopkinton, New Hampshire

Exposure Scenario:	**Case 1A**	**Case 1B**	**Case 1C**	**Case 2A**	**Case 2B**	**Case 2C**	**Case 3A**	**Case 3B**	**Case 3C**
Child's Diet:	*IEUBK Default Diet* [1a]			*Local Resident* [1b]			*Subsistence Farmer* [1c]		
Deposition Condition:	*Background*	*Location of Maximum Wet Deposition*	*Location of Maximum Dry Deposition*	*Background*	*Location of Maximum Wet Deposition*	*Location of Maximum Dry Deposition*	*Background*	*Location of Maximum Wet Deposition*	*Location of Maximum Dry Deposition*
Percent over 10 ug/dL[1]	0.003%	0.005%	0.007%	0.003%	0.005%	0.007%	0.002%	0.002%	0.002%
Age Group	**Predicted 95th Percentile Blood Lead Concentration[2] (µg/dL)**								
6 months - 1 year	3.9	4.4	4.4	3.9	4.4	4.4	3.9	3.9	3.9
1 - 2 years	4.1	4.4	4.6	3.9	4.4	4.6	3.9	3.9	3.9
2 - 3 years	3.7	4.1	4.1	3.7	4.1	4.1	3.5	3.7	3.7
3 - 4 years	3.5	3.9	3.9	3.5	3.9	3.9	3.2	3.5	3.5
4 - 5 years	3.0	3.2	3.5	3.0	3.2	3.5	2.8	3.0	3.0
5 - 6 years	2.8	3.0	3.0	2.8	3.0	3.0	2.5	2.5	2.8
6 - 7 years	2.5	2.8	2.8	2.5	2.8	2.8	2.3	2.3	2.5
Age Group	**Incremental Increase in Blood Lead Level[3] (µg/dL)**								
6 months - 1 year	--	0.5	0.5	--	0.5	0.5	--	0.0	0.0
1 - 2 years	--	0.2	0.5	--	0.5	0.7	--	0.0	0.0
2 - 3 years	--	0.5	0.5	--	0.5	0.5	--	0.2	0.2
3 - 4 years	--	0.5	0.5	--	0.5	0.5	--	0.2	0.2
4 - 5 years	--	0.2	0.5	--	0.2	0.5	--	0.2	0.2
5 - 6 years	--	0.2	0.2	--	0.2	0.2	--	0.0	0.2
6 - 7 years	--	0.2	0.2	--	0.2	0.2	--	0.0	0.2

Notes:
1. The percent of the population aged 6 months to 7 years that is likely to have a blood lead level greater than 10 µg/dL given each set of exposure assumptions. Exposure scenarios are described in Table 1.
2. Blood Lead concentrations modeled by the IEUBKwin model for each age group and set of exposure assumptions.
3. Incremental Increase in Blood Lead Level = Blood Lead Concentration during Deposition - Blood Lead Concentration during Background Conditions

FIGURES

FIGURE 1: Percentage of Lead Intake from Each Source for Different Soil Concentrations and Diets

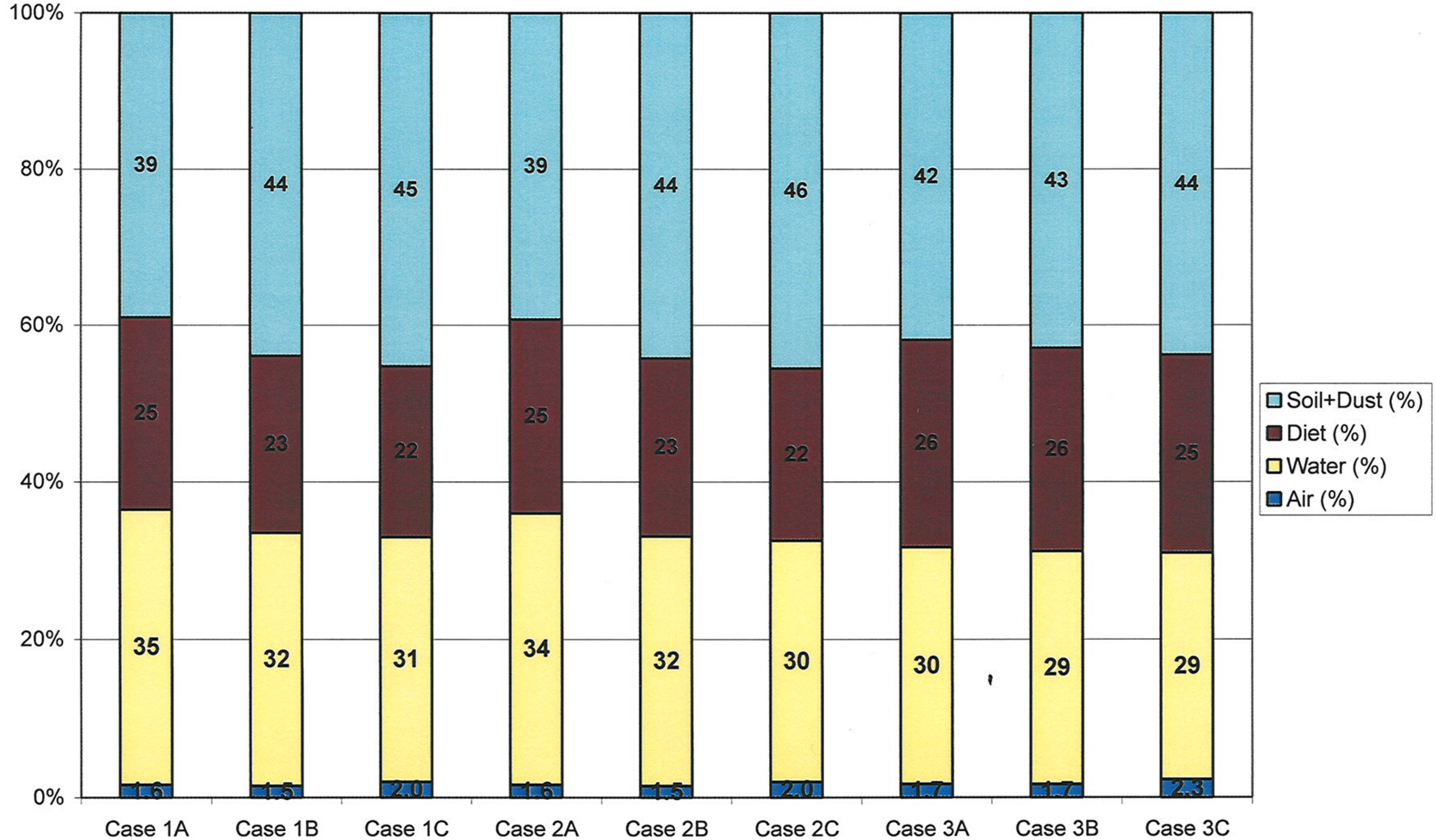
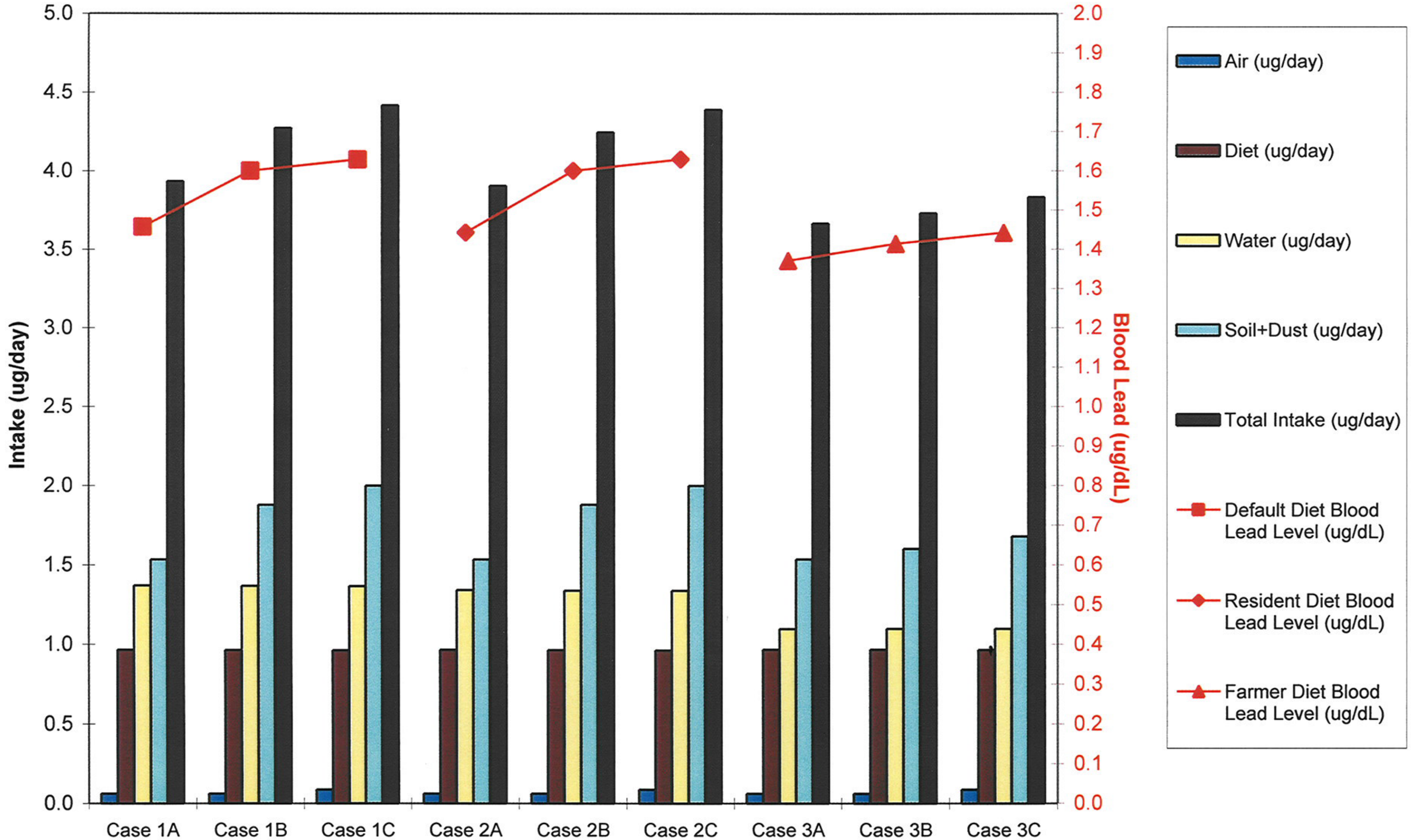


FIGURE 2: Lead Intake (ug/day) & Predicted Blood Lead Level (ug/dL) for Different Soil Concetrations and Diets



APPENDIX A

SUPPORTING CALCULATIONS

TABLE A-1
CALCULATION OF MEDIA CONCENTRATIONS AT THE LOCATION OF MAXIMUM WET DEPOSITION WITHIN THE INDUSTRIAL ZONE AND ASSUMING A SOIL MIXING DEPTH OF 1 CM

Soil Concentration due to Deposition

Soil Concentration Average over Exposure Duration

COC	Ds	tD	Cs_{tD}	ks	Cs (T_2<tD)
Lead	3.1	20	40	0.046	77.3

Variable	Decryption	Units	Value
Ds	Deposition Term	mg COC/kg soil-yr	site-specific
tD	time period over which deposition occurs (time period of combustion)	yr	20
ks	COC soil loss constant due to all proceses	yr^{-1}	site-specific

TABLE A-1 (CONTINUED)

Highest Annual Average Soil Concentration

Q	Zs	BD	Fv	Vdv	Cyv	Dywv	Dydp	Dywp	Ds
0.0756	1	1.5	0	3	0	0	0	0.61	3.1

Variable	Decription	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Zs	Soil mixing zone depth	cm	1	
BD	Soil bulk density	g soil/cm^3 soil	1.5	default
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Vdv	Dry deposition velocity	cm/s	3	
Cyv	Unitized yearly average air concentration from vapor phase	µg-s/g-m^3	constituent- and site-specific	air modeling
Dywv	Unitized yearly average wet deposition from vapor phase	s/m^2-yr	constituent- and site-specific	air modeling
Dydp	Unitized yearly average dry deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling
Dywp	Unitized yearly average det deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling

TABLE A-1 (CONTINUED)

COC Soil Loss Constant

ksg	kse	ksr	ksl	ksv	ks
0	0	0.037	0.0089	0	0.046

Variable	Description	Units	Value	
ksg	COC loss constant due to biotic and abiotic degradation	yr^{-1}	constituent-specific	--
kse	COC loss constant due to soil erosion	yr^{-1}	0	Default value because of soil eroding onto the Site and away from the Site
ksr	COC loss constant due to runoff	yr^{-1}	Site-specific	
ksl	COC loss constant due to leaching	yr^{-1}	constituent- and Site-specific	
ksv	COC loss due to volatilization	yr^{-1}	0	

TABLE A-1 (CONTINUED)

COC Loss Constant due to Runoff

RO	sw	Zs	Kds	BD	ksr
50	0.2	1	900	1.5	0.037

Variable	Description	Units	Value	
RO	Average annual surface runoff from previous areas	cm/yr	Site-specific	
sw	Soil volumetric water content	mL water/ cm^3 soil	0.2	default
Zs	Soil mixing zone depth	cm	1	
Kds	Soil-water partition coefficient	mL water/ g soil	constituent-specific	900
BD	Soil bulk density	g soil/cm^3 soil	1.5	default

TABLE A-1 (CONTINUED)

COC Loss Constant due to Leaching

P	I	RO	Ev	sw	Zs	BD	Kds	ksl
102	9.5	51	48	0.2	1	1.5	900	0.0089

Variable	Description	Units	Value	
P	average annual precipitation	cm/yr	18.06 to 164.19	102 - local conditions
I	Average annual irrigation	cm/yr	1 to 100	
RO	Average annual surface runoff from previous areas	cm/yr	Site-specific	
Ev	Average annual evapotranspiration	cm/yr	35 to 100	48 - local conditions
sw	Soil volumetric water content	mL water/ cm^3 soil	0.2	default
Zs	Soil mixing zone depth	cm	1	
BD	Soil bulk density	g soil/cm^3 soil	1.5	default
Kds	Soil-water partition coefficient	mL water/ g soil	constituent-specific	900

TABLE A-1 (CONTINUED)

Air Concentration

Q	Fv	Cyv	Cyp	Ca
0.0756	0	0	0	0.000

Q	Fv	Chv	Chp	Cacute
0.0756	0	0	0	0.000

Variable	Decription	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Cyv	Unitized yearly average air concentration from vapor phase	$\mu g\text{-}s/g\text{-}m^3$	constituent- and site-specific	air modeling
Cyp	Unitized yearly average air concentration from particle phase	$s/m^2\text{-}yr$	constituent- and site-specific	air modeling
Chv	Unitized hourly average air concentration from vapor phase	$\mu g\text{-}s/g\text{-}m^3$	constituent- and site-specific	air modeling
Chp	Unitized hourly average air concentration from particle phase	$s/m^2\text{-}yr$	constituent- and site-specific	air modeling

TABLE A-2
CALCULATION OF MEDIA CONCENTRATIONS AT THE LOCATION OF MAXIMUM WET DEPOSITION WITHIN THE RESIDENTIAL/AGRICULTURAL ZONE ASSUMING A 1 CM SOIL MIXING DEPTH

Soil Concentration due to Deposition

Soil Concentration Average over Exposure Duration

COC	Ds	tD	Cs_{tD}	ks	Cs (T_2<tD)
Lead	1.5	20	20	0.046	64.1

Variable	Decryption	Units	Value
Ds	Deposition Term	mg COC/kg soil-yr	site-specific
tD	time period over which deposition occurs (time period of combustion)	yr	20
ks	COC soil loss constant due to all proceses	yr^{-1}	site-specific

TABLE A-2 (CONTINUED)

Highest Annual Average Soil Concentration

Q	Zs	BD	Fv	Vdv	Cyv	Dywv	Dydp	Dywp	Ds
0.0756	1	1.5	0	3	0	0	0	0.30	1.53

Variable	Decription	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Zs	Soil mixing zone depth	cm	1	
BD	Soil bulk density	g soil/cm^3 soil	1.5	default
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Vdv	Dry deposition velocity	cm/s	3	
Cyv	Unitized yearly average air concentration from vapor phase	µg-s/g-m^3	constituent- and site-specific	air modeling
Dywv	Unitized yearly average wet deposition from vapor phase	s/m^2-yr	constituent- and site-specific	air modeling
Dydp	Unitized yearly average dry deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling
Dywp	Unitized yearly average det deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling

TABLE A-2 (CONTINUED)

COC Soil Loss Constant

ksg	kse	ksr	ksl	ksv	ks
0	0	0.037	0.0089	0	0.046

Variable	Description	Units	Value	
ksg	COC loss constant due to biotic and abiotic degradation	yr^{-1}	constituent-specific	--
kse	COC loss constant due to soil erosion	yr^{-1}	0	Default value because of soil eroding onto the Site and away from the Site
ksr	COC loss constant due to runoff	yr^{-1}	Site-specific	
ksl	COC loss constant due to leaching	yr^{-1}	constituent- and Site-specific	
ksv	COC loss due to volatilization	yr^{-1}	0	

TABLE A-2 (CONTINUED)

COC Loss Constant due to Runoff

RO	sw	Zs	Kds	BD	ksr
50	0.2	1	900	1.5	0.037

Variable	Description	Units	Value	
RO	Average annual surface runoff from previous areas	cm/yr	Site-specific	
sw	Soil volumetric water content	mL water/ cm^3 soil	0.2	default
Zs	Soil mixing zone depth	cm	1	
Kds	Soil-water partition coefficient	mL water/ g soil	constituent-specific	9.00E+02
BD	Soil bulk density	g soil/cm^3 soil	1.5	default

TABLE A-2 (CONTINUED)

COC Loss Constant due to Leaching

P	I	RO	Ev	sw	Zs	BD	Kds	ksl
101.6	9.5	50.8	48	0.2	1	1.5	900	0.0089

Variable	Description	Units	Value	
P	average annual precipitation	cm/yr	18.06 to 164.19	108 - local conditions
I	Average annual irrigation	cm/yr	1 to 100	
RO	Average annual surface runoff from previous areas	cm/yr	Site-specific	
Ev	Average annual evapotranspiration	cm/yr	35 to 100	48 - local conditions
sw	Soil volumetric water content	mL water/ cm^3 soil	0.2	default
Zs	Soil mixing zone depth	cm	1	
BD	Soil bulk density	g soil/cm^3 soil	1.5	default
Kds	Soil-water partition coefficient	mL water/ g soil	constituent-specific	900

TABLE A-2 (CONTINUED)

Air Concentration

Q	Fv	Cyv	Cyp	Ca
0.0756	0	0	0	0.000

Q	Fv	Chv	Chp	Cacute
0.0756	0	0	0	0.000

Variable	Decription	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Cyv	Unitized yearly average air concentration from vapor phase	$\mu g\text{-}s/g\text{-}m^3$	constituent- and site-specific	air modeling
Cyp	Unitized yearly average air concentration from particle phase	$s/m^2\text{-}yr$	constituent- and site-specific	air modeling
Chv	Unitized hourly average air concentration from vapor phase	$\mu g\text{-}s/g\text{-}m^3$	constituent- and site-specific	air modeling
Chp	Unitized hourly average air concentration from particle phase	$s/m^2\text{-}yr$	constituent- and site-specific	air modeling

TABLE A-3
CALCULATION OF MEDIA CONCENTRATION AT THE LOCATION OF MAXIMUM WET DEPOSITION WITHIN THE RESIDENTIAL/AGRICULTURAL ZONE AND ASSUMING A SOIL MIXING DEPTH OF 20 CM

Soil Concentration due to Deposition

Soil Concentration Average over Exposure Duration

COC	Ds	tD	Cs_{tD}	ks	Cs (T_2<tD)
Lead	0.076	20	1.5	0.0023	53.4

Variable	Decryption	Units	Value
Ds	Deposition Term	mg COC/kg soil-yr	site-specific
tD	time period over which deposition occurs (time period of combustion)	yr	20
ks	COC soil loss constant due to all proceses	yr^{-1}	site-specific

TABLE A-3 (CONTINUED)

Highest Annual Average Soil Concentration

Q	Zs	BD	Fv	Vdv	Cyv	Dywv	Dydp	Dywp	Ds
0.0756	20	1.5	0	3	0	0	0	0.30	0.076

Variable	Decription	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Zs	Soil mixing zone depth	cm	20	
BD	Soil bulk density	g soil/cm^3 soil	1.5	default
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Vdv	Dry deposition velocity	cm/s	3	
Cyv	Unitized yearly average air concentration from vapor phase	µg-s/g-m^3	constituent- and site-specific	air modeling
Dywv	Unitized yearly average wet deposition from vapor phase	s/m^2-yr	constituent- and site-specific	air modeling
Dydp	Unitized yearly average dry deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling
Dywp	Unitized yearly average det deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling

TABLE A-3 (CONTINUED)

COC Soil Loss Constant

ksg	kse	ksr	ksl	ksv	ks
0	0	0.0019	0.00045	0	0.0023

Variable	Description	Units	Value	
ksg	COC loss constant due to biotic and abiotic degradation	yr^{-1}	constituent-specific	--
kse	COC loss constant due to soil erosion	yr^{-1}	0	Default value because of soil eroding onto the Site and away from the Site
ksr	COC loss constant due to runoff	yr^{-1}	Site-specific	
ksl	COC loss constant due to leaching	yr^{-1}	constituent- and Site-specific	
ksv	COC loss due to volatilization	yr^{-1}	0	

TABLE A-3 (CONTINUED)

COC Loss Constant due to Runoff

RO	sw	Zs	Kds	BD	ksr
50	0.2	20	900	1.5	0.0019

Variable	Description	Units	Value	
RO	Average annual surface runoff from previous areas	cm/yr	Site-specific	
sw	Soil volumetric water content	mL water/ cm^3 soil	0.2	default
Zs	Soil mixing zone depth	cm	20	
Kds	Soil-water partition coefficient	mL water/ g soil	constituent-specific	900
BD	Soil bulk density	g soil/cm^3 soil	1.5	default

TABLE A-3 (CONTINUED)

COC Loss Constant due to Leaching

P	I	RO	Ev	sw	Zs	BD	Kds	ksl
101.6	9.5	51	48	0.2	20	1.5	900	0.00045

Variable	Description	Units	Value	
P	average annual precipitation	cm/yr	18.06 to 164.19	108 - local conditions
I	Average annual irrigation	cm/yr	1 to 100	
RO	Average annual surface runoff from previous areas	cm/yr	Site-specific	
Ev	Average annual evapotranspiration	cm/yr	35 to 100	48 - local conditions
sw	Soil volumetric water content	mL water/ cm^3 soil	0.2	default
Zs	Soil mixing zone depth	cm	20	
BD	Soil bulk density	g soil/cm^3 soil	1.5	default
Kds	Soil-water partition coefficient	mL water/ g soil	constituent-specific	900

TABLE A-3 (CONTINUED)

Aboveground Produce Concentration due to Direct Deposition

Q	Fv	Dydp	Fw	Dywp	Rp	kp	Tp	Yp	Pd
0.0756	0	0	0.60	0.30	0.39	18	0.16	2.2	0.13

Variable	Description	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Dydp	Unitized yearly average dry deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling
Dywp	Unitized yearly average det deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling
Rp	Interception fraction of the edible portion of plant	unitless	0.39	default
Fw	Fraction of COC wet deposition that adheres to plant surfaces	unitless	0.6	value for cations and most organics
kp	Plant surface loss coefficient	yr^{-1}	18	recommended
Tp	Length of plant exposure to deposition per harvest of edible portion of plant	yr-1	0.164	recommended
Yp	Yield or standing crop biomass of the edible portion of the plant (productivity)	kg DW/m^2	2.24	recommended value for above ground produce

TABLE A-3 (CONTINUED)

Aboveground Produce Concentration Due to Air-to-Plant Transfer

Q	Fv	Cyv	Bv_{ag}	Vg_{ag}	$_{a}$	Pv
0.0756	0	0	0	1	1200	0

Variable	Decription	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Cyv	Unitized yearly average air concentration from vapor phase	µg-s/g-m^3	constituent- and site-specific	air modeling
Bv_{ag}	COC air-to-plant biotransfer factor for aboveground produce	unitless	constituent-specific	0 for metals
Vg_{ag}	Empirical correction factor for aboveground produce	unitless	constituent-specific	--
$_{a}$	density of air	g/m^3	1200	

TABLE A-3 (CONTINUED)

Aboveground Produce Concentration due to Root Uptake

Cs	Br_{ag}	Pr_{ag}
53	1.36E-02	0.73

Variable	Decription	Units	Value	
Cs	Average soil concentration over exposure duration	mg COC/kg soil	consituent- and site-specific	
Br_{ag}	Plant-soil bioconcentration factor for aboveground produce	unitless	constituent-specific	1.36E-02

TABLE A-3 (CONTINUED)

Belowground Produce Concentration due to Root Uptake

Cs	$Br_{rootveg}$	$VG_{rootveg}$	Pr_{bg}
53	9.00E-03	1	4.81E-01

Variable	Decription	Units	Value	
Cs	Average soil concentration over exposure duration	mg COC/kg soil	consituent- and site-specific	
$Br_{rootveg}$	Plant-soil bioconcentration factor for belowground produce	unitless	constituent-specific	9.00E-03
$VG_{rootveg}$	Empirical correction factor for belowground produce	unitless	0.1 or 1	1

TABLE A-3 (CONTINUED)

Forage and Silage Concentration due to Direct Deposition

Q	Fv	Dydp	Fw	Dywp	Rp	kp	Tp	Yp	Pd (mg COC/ kg DW)
0.0756	0	0	0.6	0.303	0.39	18	0.16	2.2	0.13

Variable	Description	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Dydp	Unitized yearly average dry deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling
Dywp	Unitized yearly average det deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling
Rp	Interception fraction of the edible portion of plant	unitless	0.39	default
Fw	Fraction of COC wet deposition that adheres to plant surfaces	unitless	0.6	value for cations and most organics
kp	Plant surface loss coefficient	yr^{-1}	18	recommended
Tp	Length of plant exposure to deposition per harvest of edible portion of plant	yr-1	0.164	recommended
Yp	Yield or standing crop biomass of the edible portion of the plant (productivity)	kg DW/m^2	2.24	recommended value for above ground produce

TABLE A-3 (CONTINUED)

Forage and Silage Concentrations Due to Air-to-Plant Transfer

Q	Fv	Cyv	Bv_{forage}	Vg_{ag}	a	Pv
0.0756	0	0	0	1	1200	0

Variable	Description	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Cyv	Unitized yearly average air concentration from vapor phase	µg-s/g-m^3	constituent- and site-specific	air modeling
Bv_{forage}	COC air-to-plant biotransfer factor for aboveground produce	unitless	constituent-specific	0 for metals
Vg_{ag}	Empirical correction factor for aboveground produce	unitless	constituent-specific	--
a	density of air	g/m^3	1200	

TABLE A-3 (CONTINUED)

Forage and Silage Concentrations due to Root Uptake

Cs	Br_{forage}	Pr
53.41118	4.50E-02	2.40E+00

Variable	Description	Units	Value	
Cs	Average soil concentration over exposure duration	mg COC/kg soil	consituent- and site-specific	
Br_{forage}	Plant-soil bioconcentration factor for aboveground produce	unitless	constituent-specific	4.50E-02

TABLE A-3 (CONTINUED)

Beef Concentration due to Plant and Soil Ingestion

	F	Qp	P	Qs	Cs	Bs	Ba_{beef}	MF	A_{beef}
forage	1	8.8	2.5						
silage	1	2.5	2.5	0.5	53	1	3.00E-04	1	0.02
grain	1	0.48	0.85						

Variable	Description	Units	Value	
F	Fration of plant type grown on contaminated soil and ingested by the animal	unitless	1	assumed unless site-specific information is available
Qp	Quantity of plant type ingested by the animal per day	kg DW plant/day	Site- and plant-specific	
P	Concetration of COC in plant type ingested by the animal	mg/kg DW	constituent-site- and plant specific	
Qs	Quantity of soil ingested by the animal	kg/day	0.5	recommended
Cs	Average soil concentration over exposure duration	mg COC/kg soil	consituent- and site-specific	
Bs	Soil bioavailability factor	unitless	1	recommended
Ba_{beef}	Biotransfer factor for beef	day/kg FW tissue	constituent-specific	3.00E-04
MF	Metabolism factor	unitless	constituent-specific	1

TABLE A-3 (CONTINUED)

Air Concentration

Q	Fv	Cyv	Cyp	Ca
0.0756	0	0	0	0.000

Q	Fv	Chv	Chp	Cacute
0.0756	0	0	0	0.000

Variable	Decription	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Cyv	Unitized yearly average air concentration from vapor phase	$\mu g\text{-}s/g\text{-}m^3$	constituent- and site-specific	air modeling
Cyp	Unitized yearly average air concentration from particle phase	$s/m^2\text{-}yr$	constituent- and site-specific	air modeling
Chv	Unitized hourly average air concentration from vapor phase	$\mu g\text{-}s/g\text{-}m^3$	constituent- and site-specific	air modeling
Chp	Unitized hourly average air concentration from particle phase	$s/m^2\text{-}yr$	constituent- and site-specific	air modeling

TABLE A-4
CALCULATION OF MEDIA CONCENTRATIONS AT THE LOCATION OF MAXIMUM DRY DEPOSITION WITHIN THE RESIDENTIAL/AGRICULTURAL ZONE ASSUMING A SOIL MIXING DEPTH OF 1 CM

Soil Concentration due to Deposition

Soil Concentration Average over Exposure Duration

COC	Ds	tD	Cs_{tD}	ks	Cs (T_2<tD)
Lead	1.8	20	23	0.046	66.1

Variable	Decryption	Units	Value
Ds	Deposition Term	mg COC/kg soil-yr	site-specific
tD	time period over which deposition occurs (time period of combustion)	yr	20
ks	COC soil loss constant due to all proceses	yr^{-1}	site-specific

TABLE A-4 (CONTINUED)

Highest Annual Average Soil Concentration

Q	Zs	BD	Fv	Vdv	Cyv	Dywv	Dydp	Dywp	Ds
0.0756	1	1.5	0	3	0	0	0.33	0.017	1.8

Variable	Decription	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Zs	Soil mixing zone depth	cm	1	
BD	Soil bulk density	g soil/cm^3 soil	1.5	default
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Vdv	Dry deposition velocity	cm/s	3	
Cyv	Unitized yearly average air concentration from vapor phase	µg-s/g-m^3	constituent- and site-specific	air modeling
Dywv	Unitized yearly average wet deposition from vapor phase	s/m^2-yr	constituent- and site-specific	air modeling
Dydp	Unitized yearly average dry deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling
Dywp	Unitized yearly average det deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling

TABLE A-4 (CONTINUED)

COC Soil Loss Constant

ksg	kse	ksr	ksl	ksv	ks
0	0	0.037	0.0089	0	0.046

Variable	Description	Units	Value	
ksg	COC loss constant due to biotic and abiotic degradation	yr^{-1}	constituent-specific	--
kse	COC loss constant due to soil erosion	yr^{-1}	0	Default value because of soil eroding onto the Site and away from the Site
ksr	COC loss constant due to runoff	yr^{-1}	Site-specific	
ksl	COC loss constant due to leaching	yr^{-1}	constituent- and Site-specific	
ksv	COC loss due to volatilization	yr^{-1}	0	

TABLE A-4 (CONTINUED)

COC Loss Constant due to Runoff

RO	sw	Zs	Kds	BD	ksr
50	0.2	1	900	1.5	0.037

Variable	Description	Units	Value	
RO	Average annual surface runoff from previous areas	cm/yr	Site-specific	
sw	Soil volumetric water content	mL water/ cm^3 soil	0.2	default
Zs	Soil mixing zone depth	cm	1	
Kds	Soil-water partition coefficient	mL water/ g soil	constituent-specific	900
BD	Soil bulk density	g soil/cm^3 soil	1.5	default

TABLE A-4 (CONTINUED)

COC Loss Constant due to Leaching

P	I	RO	Ev	sw	Zs	BD	Kds	ksl
102	9.5	51	48	0.2	1	1.5	900	0.0089

Variable	Description	Units	Value	
P	average annual precipitation	cm/yr	18.06 to 164.19	108 - local conditions
I	Average annual irrigation	cm/yr	1 to 100	
RO	Average annual surface runoff from previous areas	cm/yr	Site-specific	
Ev	Average annual evapotranspiration	cm/yr	35 to 100	48 - local conditions
sw	Soil volumetric water content	mL water/ cm^3 soil	0.2	default
Zs	Soil mixing zone depth	cm	1	
BD	Soil bulk density	g soil/cm^3 soil	1.5	default
Kds	Soil-water partition coefficient	mL water/ g soil	constituent-specific	900

TABLE A-4 (CONTINUED)

Aboveground Produce Concentration due to Direct Deposition

Q	Fv	Dydp	Fw	Dywp	Rp	kp	Tp	Yp	Pd
0.0756	0	0.33	0.6	0.017	0.39	18	0.16	2.2	0

Variable	Description	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Dydp	Unitized yearly average dry deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling
Dywp	Unitized yearly average det deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling
Rp	Interception fraction of the edible portion of plant	unitless	0.39	default
Fw	Fraction of COC wet deposition that adheres to plant surfaces	unitless	0.6	value for cations and most organics
kp	Plant surface loss coefficient	yr^{-1}	18	recommended
Tp	Length of plant exposure to deposition per harvest of edible portion of plant	yr-1	0.164	recommended
Yp	Yield or standing crop biomass of the edible portion of the plant (productivity)	kg DW/m^2	2.24	recommended value for above ground produce

TABLE A-4 (CONTINUED)

Aboveground Produce Concentration Due to Air-to-Plant Transfer

Q	Fv	Cyv	Bv_{ag}	Vg_{ag}	a	Pv
0.0756	0	0	0	1	1200	0

Variable	Decription	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Cyv	Unitized yearly average air concentration from vapor phase	$\mu g\text{-}s/g\text{-}m^3$	constituent- and site-specific	air modeling
Bv_{ag}	COC air-to-plant biotransfer factor for aboveground produce	unitless	constituent-specific	0 for metals
Vg_{ag}	Empirical correction factor for aboveground produce	unitless	constituent-specific	--
a	density of air	g/m^3	1200	

TABLE A-4 (CONTINUED)

Aboveground Produce Concentration due to Root Uptake

Cs	Br_{ag}	Pr_{ag}
66	1.36E-02	8.99E-01

Variable	Decription	Units	Value	
Cs	Average soil concentration over exposure duration	mg COC/kg soil	consituent- and site-specific	
Br_{ag}	Plant-soil bioconcentration factor for aboveground produce	unitless	constituent-specific	1.36E-02

TABLE A-4 (CONTINUED)

Belowground Produce Concentration due to Root Uptake

Cs	$Br_{rootveg}$	$VG_{rootveg}$	Pr_{bg}
66	9.00E-03	1	5.95E-01

Variable	Decription	Units	Value	
Cs	Average soil concentration over exposure duration	mg COC/kg soil	consituent- and site-specific	
$Br_{rootveg}$	Plant-soil bioconcentration factor for belowground produce	unitless	constituent-specific	9.00E-03
$VG_{rootveg}$	Empirical correction factor for belowground produce	unitless	0.1 or 1	1

TABLE A-4 (CONTINUED)

Forage and Silage Concentration due to Direct Deposition

Q	Fv	Dydp	Fw	Dywp	Rp	kp	Tp	Yp	Pd (mg COC/ kg DW)
0.0756	0	0.3317	0.6	0.0167	0.39	18	0.164	2.24	0.24

Variable	Description	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Dydp	Unitized yearly average dry deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling
Dywp	Unitized yearly average det deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling
Rp	Interception fraction of the edible portion of plant	unitless	0.39	default
Fw	Fraction of COC wet deposition that adheres to plant surfaces	unitless	0.6	value for cations and most organics
kp	Plant surface loss coefficient	yr^{-1}	18	recommended
Tp	Length of plant exposure to deposition per harvest of edible portion of plant	yr-1	0.164	recommended
Yp	Yield or standing crop biomass of the edible portion of the plant (productivity)	kg DW/m^2	2.24	recommended value for above ground produce

TABLE A-4 (CONTINUED)

Forage and Silage Concentrations Due to Air-to-Plant Transfer

Q	Fv	Cyv	Bv_{forage}	Vg_{ag}	a	Pv
0.0756	0	0	0	1	1200	0

Variable	Description	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Cyv	Unitized yearly average air concentration from vapor phase	$\mu g\text{-}s/g\text{-}m^3$	constituent- and site-specific	air modeling
Bv_{forage}	COC air-to-plant biotransfer factor for aboveground produce	unitless	constituent-specific	0 for metals
Vg_{ag}	Empirical correction factor for aboveground produce	unitless	constituent-specific	--
a	density of air	g/m^3	1200	

TABLE A-4 (CONTINUED)

Forage and Silage Concentrations due to Root Uptake

Cs	Br_{forage}	Pr
66.08517	4.50E-02	2.97E+00

Variable	Description	Units	Value	
Cs	Average soil concentration over exposure duration	mg COC/kg soil	consituent- and site-specific	
Br_{forage}	Plant-soil bioconcentration factor for aboveground produce	unitless	constituent-specific	4.50E-02

TABLE A-4 (CONTINUED)

Beef Concentration due to Plant and Soil Ingestion

	F	Qp	P	Qs	Cs	Bs	Ba_{beef}	MF	A_{beef}
forage	1	8.8	3.21						
silage	1	2.5	3.21	0.5	66	1	3.00E-04	1	0.02
grain	1	0.48	1.14						

Variable	Description	Units	Value	
F	Fration of plant type grown on contaminated soil and ingested by the animal	unitless	1	assumed unless site-specific information is available
Qp	Quantity of plant type ingested by the animal per day	kg DW plant/day	Site- and plant-specific	
P	Concetration of COC in plant type ingested by the animal	mg/kg DW	constituent- site- and plant specific	
Qs	Quantity of soil ingested by the animal	kg/day	0.5	recommended
Cs	Average soil concentration over exposure duration	mg COC/kg soil	consituent- and site-specific	
Bs	Soil bioavailability factor	unitless	1	recommended
Ba_{beef}	Biotransfer factor for beef	day/kg FW tissue	constituent-specific	3.00E-04
MF	Metabolism factor	unitless	constituent-specific	1

TABLE A-4 (CONTINUED)

Air Concentration

Q	Fv	Cyv	Cyp	Ca
0.0756	0	0	0.522	0.039

Q	Fv	Chv	Chp	Cacute
0.0756	0	0	0.522	0.039

Variable	Decription	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Cyv	Unitized yearly average air concentration from vapor phase	µg-s/g-m^3	constituent- and site-specific	air modeling
Cyp	Unitized yearly average air concentration from particle phase	s/m^2-yr	constituent- and site-specific	air modeling
Chv	Unitized hourly average air concentration from vapor phase	µg-s/g-m^3	constituent- and site-specific	air modeling
Chp	Unitized hourly average air concentration from particle phase	s/m^2-yr	constituent- and site-specific	air modeling

TABLE A-5
CALCULATION OF MEDIA CONCENTRATIONS AT THE LOCATION OF MAXIMUM DRY DEPOSITION WITHIN THE RESIDENTIAL/AGRICULTRURAL ZONE ASSUMING A SOIL MIXING DEPTH OF 20 CM

Soil Concentration due to Deposition

Soil Concentration Average over Exposure Duration

COC	Ds	tD	Cs_{tD}	ks	Cs (T_2<tD)
Lead	0.088	20	1.7	0.0023	53.8

Variable	Decryption	Units	Value
Ds	Deposition Term	mg COC/kg soil-yr	site-specific
tD	time period over which deposition occurs (time period of combustion)	yr	20
ks	COC soil loss constant due to all proceses	yr^{-1}	site-specific

TABLE A-5 (CONTINUED)

Highest Annual Average Soil Concentration

Q	Zs	BD	Fv	Vdv	Cyv	Dywv	Dydp	Dywp	Ds
0.0756	20	1.5	0	3	0	0	0.33	0.017	0.088

Variable	Decription	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Zs	Soil mixing zone depth	cm	20	
BD	Soil bulk density	g soil/cm^3 soil	1.5	default
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Vdv	Dry deposition velocity	cm/s	3	
Cyv	Unitized yearly average air concentration from vapor phase	µg-s/g-m^3	constituent- and site-specific	air modeling
Dywv	Unitized yearly average wet deposition from vapor phase	s/m^2-yr	constituent- and site-specific	air modeling
Dydp	Unitized yearly average dry deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling
Dywp	Unitized yearly average det deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling

TABLE A-5 (CONTINUED)

COC Soil Loss Constant

ksg	kse	ksr	ksl	ksv	ks
0	0	0.0019	0.00045	0	0.0023

Variable	Description	Units	Value	
ksg	COC loss constant due to biotic and abiotic degradation	yr^{-1}	constituent-specific	--
kse	COC loss constant due to soil erosion	yr^{-1}	0	Default value because of soil eroding onto the Site and away from the Site
ksr	COC loss constant due to runoff	yr^{-1}	Site-specific	
ksl	COC loss constant due to leaching	yr^{-1}	constituent- and Site-specific	
ksv	COC loss due to volatilization	yr^{-1}	0	

TABLE A-5 (CONTINUED)

COC Loss Constant due to Runoff

RO	sw	Zs	Kds	BD	ksr
50	0.2	20	900	1.5	0.0019

Variable	Description	Units	Value	
RO	Average annual surface runoff from previous areas	cm/yr	Site-specific	
sw	Soil volumetric water content	mL water/ cm^3 soil	0.2	default
Zs	Soil mixing zone depth	cm	20	
Kds	Soil-water partition coefficient	mL water/ g soil	constituent-specific	900
BD	Soil bulk density	g soil/cm^3 soil	1.5	default

TABLE A-5 (CONTINUED)

COC Loss Constant due to Leaching

P	I	RO	Ev	sw	Zs	BD	Kds	ksl
102	9.5	51	48	0.2	20	1.5	9.00E+02	0.00045

Variable	Description	Units	Value	
P	average annual precipitation	cm/yr	18.06 to 164.19	102 - local conditions
I	Average annual irrigation	cm/yr	1 to 100	
RO	Average annual surface runoff from previous areas	cm/yr	Site-specific	
Ev	Average annual evapotranspiration	cm/yr	35 to 100	48 - local conditions
sw	Soil volumetric water content	mL water/ cm^3 soil	0.2	default
Zs	Soil mixing zone depth	cm	20	
BD	Soil bulk density	g soil/cm^3 soil	1.5	default
Kds	Soil-water partition coefficient	mL water/ g soil	constituent-specific	900

TABLE A-5 (CONTINUED)

Aboveground Produce Concentration due to Direct Deposition

Q	Fv	Dydp	Fw	Dywp	Rp	kp	Tp	Yp	Pd
0.0756	0	0.33	0.6	0.017	0.39	18	0.16	2.2	0

Variable	Description	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Dydp	Unitized yearly average dry deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling
Dywp	Unitized yearly average det deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling
Rp	Interception fraction of the edible portion of plant	unitless	0.39	default
Fw	Fraction of COC wet deposition that adheres to plant surfaces	unitless	0.6	value for cations and most organics
kp	Plant surface loss coefficient	yr^{-1}	18	recommended
Tp	Length of plant exposure to deposition per harvest of edible portion of plant	yr-1	0.164	recommended
Yp	Yield or standing crop biomass of the edible portion of the plant (productivity)	kg DW/m^2	2.24	recommended value for above ground produce

TABLE A-5 (CONTINUED)

Aboveground Produce Concentration Due to Air-to-Plant Transfer

Q	Fv	Cyv	Bv_{ag}	Vg_{ag}	a	Pv
0.0756	0	0	0	1	1200	0

Variable	Decription	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Cyv	Unitized yearly average air concentration from vapor phase	µg-s/g-m^3	constituent- and site-specific	air modeling
Bv_{ag}	COC air-to-plant biotransfer factor for aboveground produce	unitless	constituent-specific	0 for metals
Vg_{ag}	Empirical correction factor for aboveground produce	unitless	constituent-specific	--
a	density of air	g/m^3	1200	

TABLE A-5 (CONTINUED)

Aboveground Produce Concentration due to Root Uptake

Cs	Br_{ag}	Pr_{ag}
53.8	1.36E-02	7.31E-01

Variable	Decription	Units	Value	
Cs	Average soil concentration over exposure duration	mg COC/kg soil	consituent- and site-specific	
Br_{ag}	Plant-soil bioconcentration factor for aboveground produce	unitless	constituent-specific	1.36E-02

TABLE A-5 (CONTINUED)

Belowground Produce Concentration due to Root Uptake

Cs	$Br_{rootveg}$	$VG_{rootveg}$	Pr_{bg}
53.8	9.00E-03	1	4.84E-01

Variable	Decription	Units	Value	
Cs	Average soil concentration over exposure duration	mg COC/kg soil	consituent- and site-specific	
$Br_{rootveg}$	Plant-soil bioconcentration factor for belowground produce	unitless	constituent-specific	9.00E-03
$VG_{rootveg}$	Empirical correction factor for belowground produce	unitless	0.1 or 1	1

TABLE A-5 (CONTINUED)

Forage and Silage Concentration due to Direct Deposition

Q	Fv	Dydp	Fw	Dywp	Rp	kp	Tp	Yp	Pd (mg COC/ kg DW)
0.0756	0	0.33	0.6	0.017	0.39	18	0.16	2.2	0.24

Variable	Description	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Dydp	Unitized yearly average dry deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling
Dywp	Unitized yearly average det deposition from particle phase	s/m^2-yr	constituent- and site-specific	air modeling
Rp	Interception fraction of the edible portion of plant	unitless	0.39	default
Fw	Fraction of COC wet deposition that adheres to plant surfaces	unitless	0.6	value for cations and most organics
kp	Plant surface loss coefficient	yr^{-1}	18	recommended
Tp	Length of plant exposure to deposition per harvest of edible portion of plant	yr-1	0.164	recommended
Yp	Yield or standing crop biomass of the edible portion of the plant (productivity)	kg DW/m^2	2.24	recommended value for above ground produce

TABLE A-5 (CONTINUED)

Forage and Silage Concentrations Due to Air-to-Plant Transfer

Q	Fv	Cyv	Bv_{forage}	Vg_{ag}	a	Pv
0.0756	0	0	0	1	1200	0

Variable	Description	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Cyv	Unitized yearly average air concentration from vapor phase	$\mu g\text{-}s/g\text{-}m^3$	constituent- and site-specific	air modeling
Bv_{forage}	COC air-to-plant biotransfer factor for aboveground produce	unitless	constituent-specific	0 for metals
Vg_{ag}	Empirical correction factor for aboveground produce	unitless	constituent-specific	--
a	density of air	g/m^3	1200	

TABLE A-5 (CONTINUED)

Forage and Silage Concentrations due to Root Uptake

Cs	Br_{forage}	Pr
53.77246	4.50E-02	2.4

Variable	Description	Units	Value	
Cs	Average soil concentration over exposure duration	mg COC/kg soil	consituent- and site-specific	
Br_{forage}	Plant-soil bioconcentration factor for aboveground produce	unitless	constituent-specific	4.50E-02

TABLE A-5 (CONTINUED)

Beef Concentration due to Plant and Soil Ingestion

	F	Qp	P	Qs	Cs	Bs	Ba_{beef}	MF	A_{beef}
forage	1	8.8	2.66						
silage	1	2.5	2.66	0.5	54	1	3.00E-04	1	0.02
grain	1	0.48	0.97						

Variable	Description	Units	Value	
F	Fration of plant type grown on contaminated soil and ingested by the animal	unitless	1	assumed unless site-specific information is available
Qp	Quantity of plant type ingested by the animal per day	kg DW plant/day	Site- and plant-specific	
P	Concetration of COC in plant type ingested by the animal	mg/kg DW	constituent- site- and plant specific	
Qs	Quantity of soil ingested by the animal	kg/day	0.5	recommended
Cs	Average soil concentration over exposure duration	mg COC/kg soil	consituent- and site-specific	
Bs	Soil bioavailability factor	unitless	1	recommended
Ba_{beef}	Biotransfer factor for beef	day/kg FW tissue	constituent-specific	3.00E-04
MF	Metabolism factor	unitless	constituent-specific	1

TABLE A-5 (CONTINUED)

Air Concentration

Q	Fv	Cyv	Cyp	Ca
0.0756	0	0	0.522	0.039

Q	Fv	Chv	Chp	Cacute
0.0756	0	0	0.522	0.039

Variable	Decription	Units	Value	
Q	COC-specific emission rate	g/s	site-specific	
Fv	Fraction of COC air concentration in vapor phase	unitless	constituent-specific	0% for metals
Cyv	Unitized yearly average air concentration from vapor phase	$\mu g\text{-}s/g\text{-}m^3$	constituent- and site-specific	air modeling
Cyp	Unitized yearly average air concentration from particle phase	$s/m^2\text{-}yr$	constituent- and site-specific	air modeling
Chv	Unitized hourly average air concentration from vapor phase	$\mu g\text{-}s/g\text{-}m^3$	constituent- and site-specific	air modeling
Chp	Unitized hourly average air concentration from particle phase	$s/m^2\text{-}yr$	constituent- and site-specific	air modeling